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Codling Moth: Tethering Females to Determine Mating in Field Populations

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ABSTRACT

Describes a method for monitoring the mating of the female codling moth in the field, which could be used in monitoring a mating disruption program. Female codling moths were tethered on a string and placed in the orchard. The females were dissected to determine mating status. Protective containers were used to protect the tethered females from predators, especially spiders, and wind.

KEYWORDS: Codling moth, *Laspeyresia pomonella* (L.), codling moth population monitoring, insect tethering, codling moth mating.

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CODLING MOTH: TETHERING FEMALES TO DETERMINE MATING IN FIELD POPULATIONS

By D. O. Hathaway¹

INTRODUCTION

The codling moth, *Laspeyresia pomonella* (L.), is the primary insect pest of apples and pears throughout the world. With the recent developments in control of the codling moth (through such methods as the sterile insect technique, mating disruption through permeation of the atmosphere with sex pheromone, and male removal via trapping (8)²) a means of determining mating in field populations of selected pest species is of great importance. One must know whether the females are being mated in the field by native males so that enough sterile moths, pheromone, or traps can be either released or put into the orchard to obtain control or eradication. Therefore, a method such as tethering should be continually used to pinpoint areas where native populations still exist.

TETHERED MOTHS

Tethering codling moths can be done in four general ways--tethering moths in the open, in a cage, in a trap, or in a protected container. All of these ways have been used in the orchard to monitor the native population.

Fluri et al. (2) described a method used to determine the percentage of copulation in the open of the female moth when the moth was attached to a string and tied up inside of a wire cage that would protect the tethered females from birds but not other predators.

Cardé et al. (1) used 1-day-old virgin laboratory reared females for tethering. The technique they used was to denude the dorsum of the thorax by removing scales with a fine brush and placing glue on the denuded area and on the end of a fine black thread 5 cm long. They then joined drops of cement on the thread and thorax and attached the thread to the bottom of a nonsticky Pherotrap 1C® trap. The trap was suspended about 2 cm above the ground. This trap did

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²Italic numbers in parentheses refer to Literature Cited, p. 5.

not afford the tethered moth protection from vespids and other predators that may be present in the orchard.

The use of tethering as a means of monitoring mating has been tried with *Zodion obliquefasciatum* (Macq.), a parasite of the alkali bee. Howell (6) showed in replicated tests that when virgin females were immobilized with a white thread tied to a leg and were stationed on a weed, no males attempted to mate with any of the tethered females; however, females that were nearby with clipped wings mated normally. Howell concluded that the thread distracted male flies and they avoided it. In some insects, this method of tying the tether to the female would not work because the insect would tear its leg off trying to escape.

Oyama (10) reported that the mating of *Spodoptera litura* (F.) can be suppressed by evaporation of liture B ((9Z,12E)-9,12-tetradecadinyl acetate), the minor component of the female sex pheromone of this species. An account is given of field studies in Japan in which he used tethered females as a means of determining effective range for suppression.

Experiments were conducted with tethered females in our laboratory and the field from 1973 to 1976 to determine if female codling moths could be used for monitoring mating and what techniques for their use were necessary. The technique appeared to be practical, but it should be stressed that we made improvements in the technique that are essential for use in orchards in the West. We found that a container that afforded protection to the moth from wind and predators was essential for good recovery of the tethered females.

In recent years, there has been much interest in monitoring populations of codling moth by using traps baited with live females or with the synthetic sex pheromone. The information obtained is currently being used in timing applications of insecticides; however, another method of monitoring mating of the codling moth in the field is needed for our research studies, especially if mating disruption is to be used for control. Therefore, laboratory and field experiments with tethered females were made in 1973-75. The technique appeared to be practical, but tethered females were lost because of wind and predators. As a result, containers that might give protection to the tethered moths were tested during the winter of 1975-76 in the laboratory and also in the field in the summer of 1976. The entire series of laboratory and field tests is reported here.

PROCEDURES AND TESTS

Laboratory Studies

In March 1973, a preliminary laboratory experiment was made to determine whether female codling moths would mate when they were tethered on a string. A 1.2- by 1.2- by 0.9-m screen cage was set up with 50 tethered females that had been treated with 25 krad gamma irradiation and 50 unirradiated loose males; the test was replicated five times. The temperature of the test was kept at $27^{\circ}\text{C} \pm 2^{\circ}$ and about 40 to 50 percent relative humidity (RH). After 7 days, the females were removed and put into vials of alcohol. They were dissected for spermatophores within 5 days, and mating was determined. The experimental insects were obtained by rearing larvae on immature apples (3, 4, 5).

Field Studies

I put tethered females out in the field in an orchard in the Wenas Valley to monitor mating. The virgin insects were obtained by placing individual flutes of corrugated cardboard containing a pupa into individual 1½-dr shell vials. The vials were capped, and the pupae were held until the adult moths emerged. Then the insects were chilled so they were immobile and were irradiated at 25 krad (if the insect escaped from its tether, it could not infest the orchard).

After irradiation, the tethered females again were immobilized by placing them on a thermoelectric cold plate or a plastic gel refrigerant icepak. Then, the scales were pulled away from the thorax with a small needle-type knife until only a smooth surface was left. (The knife had to be dipped into cement two or three times so the scales would adhere to it while they were being removed). A small drop of rubber cement was next applied to the thorax of the moth, and the tether (a length of cotton thread 7.62 to 10.16 cm long) was attached.

The tethered insects were placed in a 30-ml plastic jelly cup, a lid was snapped on the cup, and the cups were placed in an ice chest cooled to about 10°C for transportation to the orchard. At the orchard, the tethers were tied to push pins that had been put into an apple limb. Insects used in the tests were 1 to 48 h old.

Between May 9 and Aug. 31, 1973, 879 tethered females were placed in the orchard. In 1974, from June 5 to Aug. 11, 153 tethered females were exposed, but this time in apple trees that had had no chemical treatment for several years. With higher populations and no direct competition from pheromone-baited traps, 42.8 percent of the 36 percent recovered were mated. Because of spiders and certain species of Raphidiidae preying upon the tethered female codling moths, in 1976, a 1.1-L ice-cream carton (fig. 1) with one-half of the ends removed (so the native males could enter) was used to protect the tethered females from wind and predators (3.8- and 0.6-L ice-cream cartons were tested but 1.1-L cartons seemed to be quite satisfactory for most of the experiments). The ice-cream carton was soaked in a solution of propargite (2-(p-tert-butylphenoxy)cyclohexyl-2-propynyl sulfite) for at least 2 min to treat the inside and outside of the carton.

RESULTS

I detected no undesirable side effects on mating due to the irradiation of tethered females. The data indicated that 60 percent of the tethered females mated in the laboratory. Fifty percent of the 879 tethered females tethered in 1973 were recovered, but only 0.68 percent were found mated in the orchard. In 1975, however, when similar tethered moths were again stationed in the Wenas orchard (July 9-23), 44 of the 76 put out were recovered, but only 2.2 percent were mated. Then, either one or five tethered female moths were placed inside each carton. The propargite had no detrimental or inhibiting effects upon the codling moths when used to soak the ice-cream carton and helped to prevent predators, especially spiders, from preying upon tethered females.

Table 1 shows results of the field experiments. Single isolated tethered



Figure 1.--Tethered females in 1.1-L carton used for protection from predators, especially spiders and wind. One end of carton removed.

Table 1.--*Mating of tethered female codling moths exposed in 1.1-L carton treated with propargite, Yakima, Wash., 1976*

Dates of tests	Tethered moths observed	Females recovered		Females mated	
		1 ♀/carton	5 ♀/carton	1 ♀/carton	5 ♀/carton
	<i>Number</i>	<i>Percent</i>			
July 5-14	24	66	70.0	37.5	83.0
15-21	26	69	57.6	31.7	73.0
22-28	23	60	60.8	43.4	87.0
Total ¹	73	65.7	63.0	36.9	80.0

¹Total tethered and average recovery and mating.

females in the treated cartons mated only 36.9 percent of the time, somewhat less frequently than would be expected. Apparently, tethering, caging, and handling interfered with mating success; however, groups of females (five per cage) were 80-percent mated. Similar results were obtained by Fluri et al. (2). Howell et al. (7) and Nowosielski et al. (9) also found that groups of codling moths showed higher mating frequencies than did isolated pairs.

DISCUSSION

A major problem was the physical effect of strong winds upon maintenance of the tether. In the Wenas orchard, strong northwest winds caused the bond between the string and the moth to break, and the moth was lost. Tethered females were in direct competition with traps because the population was extremely low and the orchard was part of a study on male trapping. Another problem was that spiders took the abdomen of the tethered females as they rested on the leaves or branches; the insect's head, thorax, and wings remained attached to the tether. In addition, certain species of Raphidiidae preyed upon the tethered codling moths.

CONCLUSIONS

The research reported on in this publication has demonstrated that tethered females can be used to monitor the mating of a codling moth population. This technique will be used in our laboratory as one tool to monitor the efficiency of programs (such as sterility and mating disruption) for control of the codling moth. Rauscher (11) reported that (Z)-9-dodecenyl acetate, the major sex pheromone component of the European grape berry moth, *Euroecilia ambiguella*, was continuously evaporated from 110 sources in a 20- by 20-m plot in a vineyard. Inhibition of mating was demonstrated by releasing laboratory-reared males and exposing tethered females.

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